

**INFORMATION SECTION****(The numbers relate to numbers in the Students Notes and Exchange Form)****Part 2 Growing plants on a large scale****3. Growing decisions about local crops****What minerals do plants need from the soil?**

All plants need a combination of different minerals. Each mineral might have several functions in a plant. Some plants are affected by a lack of a particular mineral more than others. This table shows why they are needed and the signals that tell you if a plant is lacking (or 'deficient in') one particular mineral.

<b><i>Minerals</i></b>	<b><i>Why do plants need them?</i></b>	<b><i>Visible symptoms of a deficiency*</i></b>	<b><i>Causes of deficiency</i></b>
<b>Nitrogen (N)</b>	Important component of chlorophyll and for making plant proteins used in growing new shoots and leaves (especially important for leaf vegetables like spinach).	Leaves become yellowed (particularly older, lower leaves) and plants will be stunted.	Nitrogen is easily washed away (leached) in open, uncovered or sandy soils.
<b>Phosphorus (phosphate) (P)</b>	Mainly responsible for good root growth.	Slow growth, especially soon after emergence, and underdeveloped root system. Leaves show a blue or purple colouration, with older leaves affected first.	
<b>Potassium (potash) (K)</b>	Essential for synthesis of proteins and sugars. Needed for good overall growth, especially development of flowers and fruit.	Slow growth affecting size and quantity of fruit and flowers. Older leaves, show yellowing around edges followed by brown scorching and will curl up or down.	
<b>Magnesium (Mg)</b>	Very important ingredient for making chlorophyll.	Yellowing which starts between the veins on older leaves to give a mottled appearance.	Too much potassium or not enough organic matter in the soil creating a bad soil structure.
<b>Calcium (Ca)</b>	Helps neutralise some acids and the manufacture of	Affects young leaves and can be seen as cupping and burning of the leaf	Insufficient organic matter (compost and manure) in soil.

	protein.	tips. Younger leaves are blackened.	
<b>Sulphur (S)</b>	Important in making plant protein and chlorophyll.	Slow and stunted growth. New leaves are uniform golden yellow colour and might be cupped or deformed.	Insufficient organic matter (compost and manure) in soil.
<b>Trace Elements</b>			
<b>Iron (Fe)</b>	Essential for plant growth, but only needed in small quantities.	Yellowing between the veins of older leaves and nearly white younger leaves.	
<b>Manganese (Mn)</b>		Yellowing between the veins of younger leaves.	
<b>Copper (Cu)</b>		Varies with plant species. New leaves become greyish green, yellow and sometimes white.	
<b>Chlorine (Cl)</b>		Wilting	
<b>Zinc (Zn)</b>			
<b>Boron (B)</b>			
<b>Molybdenum</b>		Deformed growth and 'whiptail' in brassicas.	Linked to acid soils.

## 5. Researching the issues

### Case Study 1 Organic fertilizers improve produce quality

In Ghana, tomatoes are an important ingredient in the majority of local dishes, and can provide a source of income at local markets for small-scale farmers. Researchers working with the near-urban poor explored alternative livelihood options and more equitable approaches to village land management and soil fertility through improved use of various urban wastes. Production from tomatoes grown using cow or poultry manure, was compared with those grown under the usual chemical fertiliser treatment. Fruit grown using a chemical fertiliser had a shorter shelf life and was found to be more watery, a characteristic that reduces the quality of fruit for cooking.

DFID Natural Resources Systems Programme

### Pests and Diseases

To find information and identification pictures about common pests and diseases that might be affecting plants in your local area, try looking in local gardening books. The useful websites listed at the end of this section will also help you.

## 5a. To spray or not to spray?

### **What is a pesticide\*?**

A pesticide is a chemical substance that is used to destroy or repel any pest. Pests can include unwanted insects or other animals (such as mice and rats), plants (weeds), fungi or micro-organisms like bacteria and viruses.

Pesticides include insecticides (for insects), herbicides (for weeds), fungicides (for fungi) and various other types of chemical substances used to get rid of pests.

### **Identifying a problem**

If a plant is not growing well it is important to find out what the problem is, before looking for a way to deal with it. The problem may be from weather damage, a virus, lack of particular minerals in the soil, a pest (insect or animal) or a disease (bacterial, viral or fungal).

To identify a problem, the best action to take is to ask expert growers in your local community who have local knowledge (for example, gardeners, farmers and agricultural college staff); or contact specialist organisations for advice and help such as local garden centres and regional agricultural or plant research centres.

### **Avoiding the pest problem**

Some pests can be controlled without using chemical pesticides by natural methods. One of the best natural methods is to encourage a population of natural predators (Farmers' Friends). Farmers and gardeners do this by providing flowering plants and creating habitats which will attract pest predators (insects and other animals) into the garden.

Farmers are increasingly using integrated pest management (IPM) which uses natural methods as much as possible and chemical insecticides only when absolutely necessary for specific problems. Crop rotations, intercropping, mulches, sowing several varieties of a crop and keeping seed beds clean all help to reduce the number of pests in the garden or farm.

To find out more about Farmers Friends in your area, try looking in gardening books and /or use the 'Farmers Friends' poster.

DFID Crop Protection Programme [www.cpp.org.uk](http://www.cpp.org.uk)

**Case study 2 Rice and Integrated Pest Management (IPM) in Bangladesh**

Rice is grown mainly in sub-tropical and tropical countries and is the main food source for three billion people – almost half the world's population.

**The problem**

Pests, diseases and other environmental factors can seriously affect the quality and yield (amount in tonnes) of a rice crop. Because of this, rice uses the most agro-chemicals (fertilisers and pesticides) of all the commercially grown crops. About \$3.75 billion US are spent every year on agro-chemicals for rice. Rice uses up a lot of water, and is often grown in places where local water resources are a problem. This means that the need to reduce the amount of chemicals used is even more important as there is a risk that the chemicals could pollute precious drinking water.

**The IPM solution**

Hindu farmers from Bahaguli village in Bangladesh have started doing 'rice-fish culture'. This involves putting fish in the flooded rice fields and leaving the field free from any chemical pesticides or herbicides.

There are many benefits to this system:

- Farmers had found that some chemical fertilisers turned the rice plant a certain green colour that attracted plant pests, and the chemicals used to destroy the rice pests also destroyed insects that are good for the crop.
- Spiders, ladybirds, damselflies and wasps will control rice pests at no cost.
- Incomes improved as the farmers were able to sell fish as well as rice.

Today the only fertiliser applied is cow dung and vegetable matter. Weeds are controlled by hand which also deprives the pests of places to live and breed. Vegetables are grown on the river dykes, so families now have a much healthier diet, and avoid the long travel distances to market for these.

**Case Study 3 Cotton and Integrated Pest Management (IPM) in India**

India produces 2.5 million tons of cotton each year (over 50% of the world's cotton), and this sustains the livelihoods of over 17 million people. Most of these are poor farmers who must support their families on less than 2 hectares of land. For these smallholders, the cotton crop is often the only source of income for food, medicines, education and shelter.

**The problem**

Unfortunately, cotton crops have become less and less productive because of the increasing cost of pest control. The main pest is the cotton bollworm. The pesticides can account for more than 40% of the cost of growing the cotton.

Poor spraying techniques and over-use of chemicals has led to the pest becoming resistant to most of the available insecticides. Seeing their crops devastated by bollworms, and desperate to salvage something from their losses, farmers have continued to buy more toxic (and expensive) chemicals and to spray more frequently, but with decreasing effectiveness. The cost of chemicals has pushed farmers into dramatically increasing spirals of debt and in some cases suicide.

**The IPM solution**

Farmers, working with UK and Indian scientists, encourage the build up of the bollworm's natural predators and target limited sprays of recommended insecticides on the pest only when absolutely necessary.

Reduced costs of production and increased yields of cotton result in massively increased incomes to farmers. Farmers' strong enthusiasm generated by the results from this experiment attracted widespread media coverage. Recognising the potential of these improved pest control methods, the Indian Ministry of Agriculture is now funding promotion of IPM in 500 villages in the 20 major cotton districts. As these regions currently use 80% of the *total* insecticide used on cotton in India, there is real potential for an even bigger reduction in pesticide use.

DFID Crop Protection Programme [www.cpp.org.uk](http://www.cpp.org.uk)

**Case Study 4 Innovative pest control**

Fruit fly damage to fruit crops in Pakistan deprives poor households of an important, nutritionally valuable food source. Consumption of fly infested fruit can cause diarrhoea, especially in children, adding to existing problems of malnutrition.

Alternative control methods use 'bait spots', in which a protein source (needed by the flies to mature their eggs) is mixed with a very small quantity of insecticide. These kill the flies more effectively than traditional blanket sprays over a whole area and reduce the amount of insecticide used by 95%. Whilst being cheap, a more easily prepared home-made meat broth has approximately 71% effectiveness, per unit volume, compared to the commercial bait.

DFID Crop Protection Programme [www.cpp.org](http://www.cpp.org)

**Case Study 5 Reducing the need for herbicides in Asia****Zero-tillage with wheat and rice**

Farmers that grow both wheat and rice in Asia have been testing and sharing a system called zero-tillage. When the rice has been cut, the short stalks form 'stubble' that is left behind. Rather than clearing this stubble away and tilling the soil before planting their wheat seeds, farmers have sown the wheat seeds directly into the rice stubble.

This has an astonishing range of benefits.

- 1) The farmers' costs (fuel, tractor rental or maintenance, water pumping) are reduced because only a single tractor pass is needed – to sow the seeds. So less diesel is used and less carbon dioxide produced.
- 2) The wheat is sown earlier and gets established quicker which means that weeds don't get a chance to be established before the wheat plants can shade them out.
- 3) This reduces the need for herbicides.
- 4) In many cases, yields improve because the grain matures before the pre-monsoon heat can wilt it.
- 5) Since the system enables wheat to take advantage of the moisture left behind by the rice harvest, zero-tillage saves farmers around 1 million litres of water per hectare.

International Wheat and Maize Center (CIMMYT), Mexico [www.cimmyt.org](http://www.cimmyt.org)

**5b. Choosing a Cropping System.....**

A whole range of different cropping systems can be used to promote more efficient crop production. A few examples like crop rotations, intercropping and seed priming are described below. Some of these reduce the need to use costly chemical inputs on the farm or make crop growth more efficient to increase the yield harvested. This helps increase the profit (income from sale of produce less cost of inputs) to the farmer from his harvest.

**Crop Rotations**

Crop rotation is a traditional system where land is subdivided into separate plots and the crops on each plot are changed every year in a sequence (or in rotation). This system stops pests and diseases that are particular to one type of plant from getting a hold in the soil and helps to maintain soil fertility, controls weeds and helps a good variety of natural predators to survive on the farm.

For example, nitrogen is important to plants, particularly for helping leaves to grow. The air is 78% nitrogen but most plants are unable to use nitrogen directly from the air as a gas. They get it from the soil. Legumes, like peas and beans can 'trap' nitrogen from the air by using bacteria which live in their roots. They are called nitrogen-fixing plants.

When legumes are planted, they increase the amount of nitrogen in the soil. This nitrogen will then be available to the plants that are planted next in the rotation

sequence. By using this method, gardeners or farmers can reduce or stop using chemical nitrogen fertilisers.

In a vegetable garden rotation, a leafy crop which requires a lot of nitrogen, like cabbage (a brassica), can follow a legume.

Year 1	Year 2	Year 3
<b>Three year crop rotations for a vegetable garden:</b>		
Legumes (beans or peas) Fix or trap nitrogen	Brassicas (cabbage, broccoli) Need lots of nitrogen	Root crops (carrots, parsnips, turnips).

In a larger farm field-crop rotation, a legume crop like alfalfa (green manure) is normally planted every two years, rather than every four in vegetable gardens. This is because vegetable gardens have usually had extra manure and mulch added to help with fertility and need less help from green manures.

### Examples of field and vegetable crop rotations around the world

Season	Vegetable Crop Rotation		Field Crop Rotation	
	Semi-Arid Region	Sub-Humid Region	Semi-Arid Region	Sub-Humid Region
1	Pumpkin	Amaranth	Soyabean (legume)	Rice
2	Onion	Tomato	Maize	Rice Bean (legume)
3	Chickpea (legume)	Mung Bean	Groundnut (legume)	Cassava
4	Capsicum	Bottle Gourd	Millet	Green manure/Fodder (legume)
5	Kale	Capsicum		

Burgess, A; Maina, G; Harris, P; and Harris, S. (1998). VSO Books. ISBN: 0 95090 50 6 2.

### Inter-cropping

This means mixing different crops together in one planting area, or plot. Farmers choose plants that do not compete for resources (such as minerals, water or light). For example deep-rooted plants may be planted with shallow-rooted plants that draw moisture from different levels in the soil, or plants with different leaf shapes may be planted together to make best use of the available sunlight.

*In South America maize was grown with beans and squashes in mixed cropping systems. Maize needs nitrogen and beans fix nitrogen from the atmosphere. The beans climb up the stems of the maize. Squash grow on vines on the ground, their spreading leaves keeping down weeds and helping to retain soil moisture. An excellent partnership all round, saving fertilizers and weeding.*

Jo Readman, Eden Project

### Seed Priming

Once sown, seeds spend a great deal of time just absorbing water from the soil. If this time is minimised by soaking seeds in water before sowing (seed priming), seed germination and seedling emergence is more rapid and crop yields are increased. Farmers from Nepal to Botswana have used this technique for generations to “catch up” on time lost in a drought year. Safe limits to soaking times, which if exceeded, could lead to seed or seedling damage - have been calculated for a wide range of tropical and sub-tropical crops. In most cases seed can be primed overnight and then surface-dried and sown the same day. Occasionally, sowing may be unavoidably delayed - by heavy rain for example. If primed seed is surface-dried and kept dry it can be stored for several days then sown as usual and still perform better than non-primed seed.

### On-farm seed priming of crops

Crop	Soaking time (hours)		
Wheat	12	Chickpea	8
Mungbean	8	Barley	12
Finger millet	8	Upland rice	12-18
Cowpea	8	Maize	12-18
Bambara groundnut	8	Sorghum	10
Linseed	8	Pearl millet	10
Pigeonpea	8	Groundnut	8

Ref: DFID Plant Sciences Programme [www.psp.org](http://www.psp.org)

## 5c. Creating a better seed Plant breeding... traditional to modern

### What are genes?

Genetic diversity means that each individual plant or animal has a slightly different mix of genes. Each gene, along with the environment, creates individual physical characteristics of the plant/animal. Plants from the same crop species therefore will have different characteristics: some may be taller, some may have higher yields, and some may be more resistant to a disease. Farmers and gardeners are interested in developing the best individuals for their environment – so that they can get the best crop from their harvest. Farmers aim for plants that are high yielding, resistant to disease and which can withstand local environmental conditions.

### Traditional Methods

Traditional crop varieties are the result of many years of selection by farmers. Seeds are saved from the best crops of the harvest, and stored to use in the following planting season. This means that seeds are collected from the highest yielding plants, or the plants that have survived well in local environmental conditions. In the next season, the plants that grow from these seeds will pollinate each other, hopefully



producing a stronger offspring plant. Over time, picking the best seeds from one year to the next, will gradually breed the strongest crops for that particular environment.

Farmers develop their knowledge and expertise - how and when it is best to plant, care for growing plants, harvest and store their seeds. However, sometimes, in extreme environments where it is difficult to grow strong plants (where the soil is poor, or salty, or arid areas where rainfall is unpredictable) traditional breeding will sometimes fail to produce plants that are strong enough to produce enough reliable food for the population. Modern plant breeding methods can help.

### Case Study 7 Esther's bean

80 year old Esther is a respected bean grower in western Kenya. She sells seed to other farmers and leads a women's group that experiments with bean varieties and cultivation methods. One new variety is referred to locally as "Esther's Bean". It resists root rot, matures early – plant in March, eat in May – sells for a good price, cooks quickly and tastes good. Last year Esther sold enough beans to buy a bull for ploughing and mating with heifers. The bull was born on Kenya's Independence Day, Jamhuri, so she called it Jamhuri Beans.

International Center for Tropical Agriculture (IITA), Nigeria [www.ciat.cgiar.org](http://www.ciat.cgiar.org)

### Modern Methods

Modern plant breeding methods can produce seeds with particular characteristics. These seeds, called **hybrids\***, are created by crossing two different inbred lines of the same plant species, to get the best chosen characteristics from each. This method can produce plants that are all the same as each other, and can result in predictable, strong and uniform yields, which is an advantage to the modern farmer. Another advantage is that plants can be bred to produce seeds that are resistant to particular diseases or pests.

However, hybrids can have some important drawbacks compared to the traditional 'seed saving' system. For example: -

1. Although their seeds can be saved for planting in the next year, the plant that grows may not be the same as either of its parents. This means that farmers have to buy new seed every year from the company or breeder who has developed the seed. For poorer farmers, seed saving may be a better method as in years where there is little money, they can guarantee having seeds to plant for the next food crop.
2. Hybrid seeds can produce a uniform crop where all the plants are the same and this means that the characteristics of the plants can be predicted. But it also means that the whole crop is vulnerable to an unexpected pest or disease. This may lead to a farmer having to invest in more chemical inputs to spray for pests and diseases. In the traditional 'seed saving' system, each individual plant is slightly different so if a pest

or disease attacks a field, or a season has unusual weather, at least some of the crop may survive.

### **What is GM?**

You may have heard a lot about food containing GM crops, but do you know what GM stands for? GM stands for **genetic modification** or **genetically modified**. It is the technique of taking genes from one organism to put into another. In other words scientists can take genes from one plant and put them into another plant, they don't necessarily have to be of the same species. This transfers useful genes that carry characteristics such as disease or herbicide resistance, increase in crop production or improved stress tolerance, so enabling the new plant to display these beneficial characteristics.

## **Part 3 Finding solutions to local problems**

### **6. Action plans**

#### **The Challenge of Sustainability**

New technologies have boosted agricultural production worldwide, but some have had harmful side effects, for example: resistance of insects to pesticides, land degradation through wind or water erosion, nutrient depletion of soils, or poor irrigation management, and loss of biological diversity. In the long term, increasing food production depends on using natural resources sensibly, not destroying them. Making sensible, sustainable use of natural resources is important for future generations as well as us.

In agricultural production, farmers try to follow three main objectives:

- 1) improving efficiency in the use of resources and inputs;
- 2) increasing the resilience of the farming system to changes in socio-economic and environmental conditions;
- 3) promoting diversity, through varied farming systems that help spread the farmer's risks and use of time.

For example, for smallholder farmers, mixed farming systems not only help promote maximum efficiency in natural resource use, but also help provide access to a balanced diet. Livestock on the farm can be used to plough the soil, and can provide dairy products and meat protein. Crop residues provide livestock feed. Livestock manure provides crop fertilisers.

#### **Useful general websites**

##### **The Royal Horticultural Society [www.rhs.org.uk](http://www.rhs.org.uk)**

Look at the advice section for help with growing plants and finding out why plants are not growing well (pests, diseases, nutrient problems or weather damage)

##### **The Henry Doubleday Research Association [www.hdra.org.uk/schools](http://www.hdra.org.uk/schools)**

Look at the tips and advice section for downloadable fact sheets about organic gardening and controlling pests and diseases.

Also look at the pest management and ‘farmers friends’ posters which can be printed from the pdf files.



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